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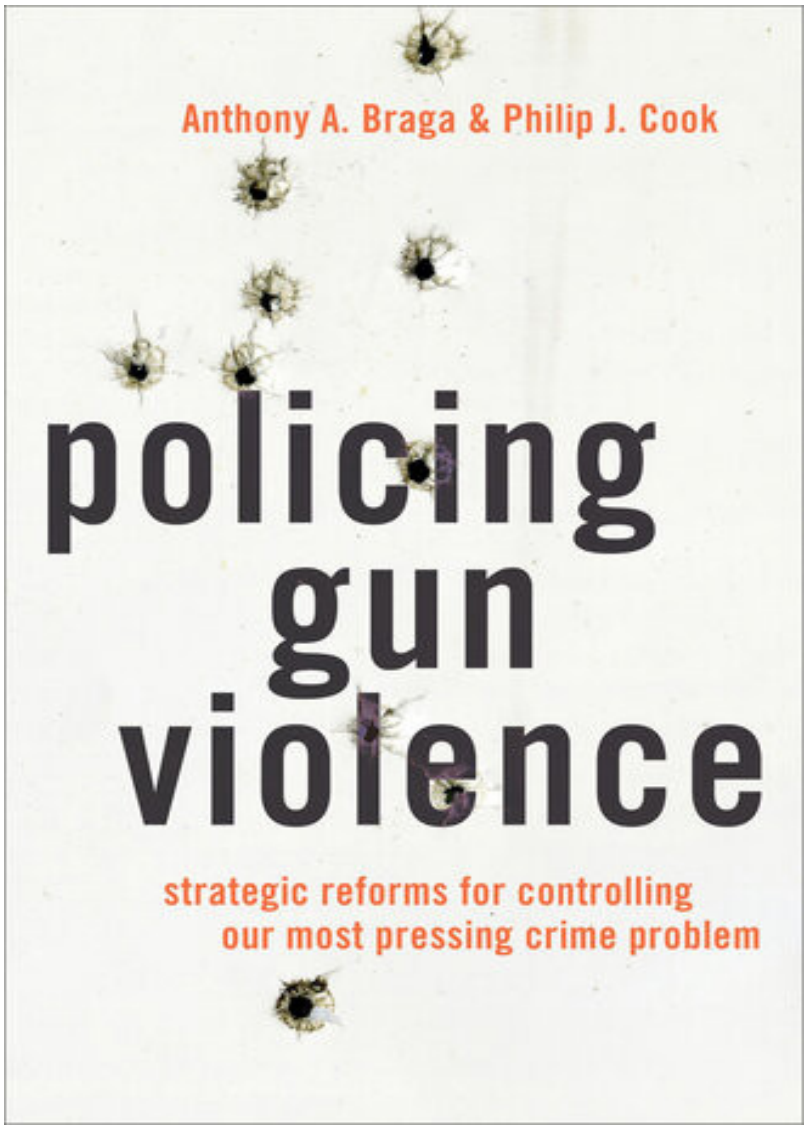

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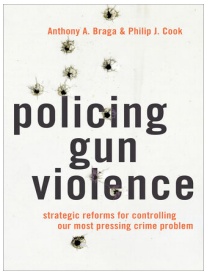
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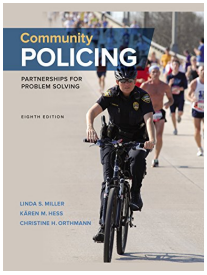

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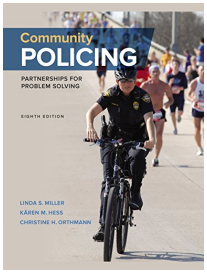

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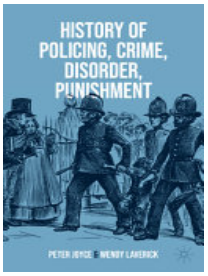

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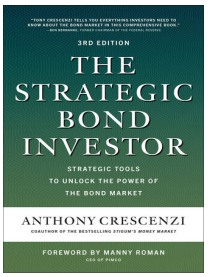
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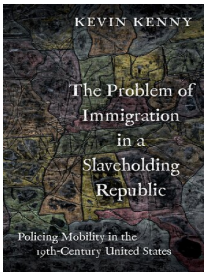
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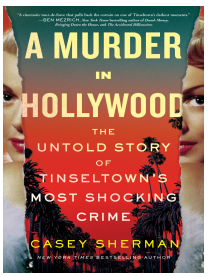

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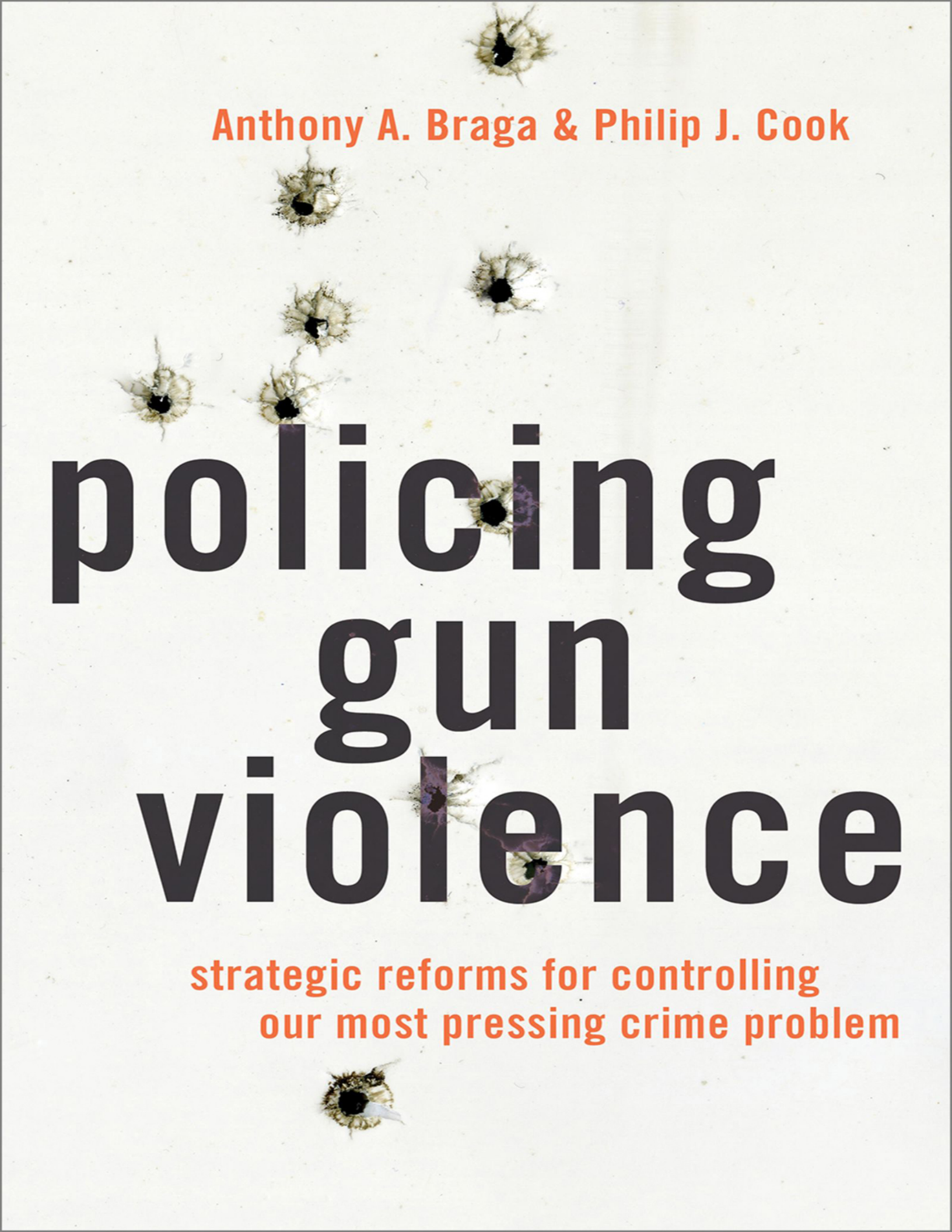

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Contents

Acknowledgments

1. **Introduction**
2. **The Social Burden of Gun Violence**
3. **Regulation and Its Enforcement**
4. **21st-Century Policing and Crime Control**
5. **Targeted Patrol and Problem-Solving in Hot Spots**
6. **Retail Deterrence of Very High-Risk Groups**
7. **Strengthening the Investigation of Shootings**
8. **Reducing Shootings by the Police**
9. **Policing Firearms Trafficking, Theft, and Illegal Diversion**
10. **There's Much to Be Done**

Notes
Index

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1
Introduction

2020 was the year from hell. Along with the coronavirus pandemic and all that entailed, there was a surge in shootings in most cities, actually doubling in New York City. Nationally, the murder rate increased by 28%, and by the end of this fateful year it approached levels in some cities not experienced since the crack cocaine era a generation earlier. This surge in gun violence occurred in an unusual economic and political context, but the legacy of the street protests against the police, the surge in gun sales, and the mental health crisis induced by the disruptions of everyday life will not subside any time soon. What we can say with confidence is that the problem of gun violence in America, always urgent, became still more so.

What can be done to control gun violence? First is to recognize its importance. Public safety is foundational to human development, economic development, and a civilized life—and communities beset by violence are deprived in all those respects. The fact that those communities are for the most part lower-income minority households makes the problem still more urgent. The "public safety gap" is one of the most egregious racial disparities.

Gun violence is a multifaceted problem requiring a multifaceted response. But an essential component of any comprehensive effort is more effective policing. Most instances in which one person shoots another are crimes. The police offer a unique capacity for violence prevention that has no good substitute from other institutions, and effective policing could prevent much of the shooting. But to accomplish that purpose, and do so in legitimate fashion that respects individual rights, is a daunting challenge. The good news is

that much has been learned in recent years about how to meet that challenge, due in part to innovative police departments that have partnered with analysts such as us to try out new strategies and evaluate them.

There is no consensus with respect to this positive assessment, quite the contrary. The police do not get much respect these days. Some doubt that police departments are even concerned with protecting the communities of color that bear a vastly disproportionate share of the burden. Widespread demonstrations throughout the summer of 2020 demanded *not* that the police be reformed but, rather, that they be "defunded." This bitter attack was triggered by the video of a Minneapolis, Minnesota, police officer using clearly excessive and cruel lethal force in arresting George Floyd. A dozen videos of other deadly encounters between police and Black suspects have circulated widely in recent years, with cumulative effect. The outrage and profound mistrust of the police fuel the "no snitching" norm, depriving police investigators of the cooperation needed to solve cases. If the police are unable to make arrests in the majority of shootings, in part due to lack of cooperation, that failure reinforces the community view that the police do not care. But given the necessary resources and direction, this vicious circle can be reversed.

A second group of skeptics includes our colleagues in criminology and public health. A prevalent view among academic criminologists circa 1990 was that the police had little effect on crime rates.[1] That was not because the police were not trying hard enough but, rather, because law enforcement was intrinsically irrelevant. In this view, crime rates were determined by "root causes" found in systemic inequality, lack of economic opportunity, inadequate schools, drug and alcohol abuse, popular culture, and so forth. At the time, violent crime rates were peaking at unprecedented levels, and police chiefs throughout the country gladly embraced the criminologists' view that the police were irrelevant and hence not to blame. But that comfortable view was ultimately undercut by a handful of police executives, most notably William Bratton. Bratton was appointed

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Commissioner of the New York City Police Department twice, the first time beginning in 1994. In these and other leadership positions, he accepted responsibility for reducing crime and insisted that his commanders view crime as a problem to be solved.[2] The extraordinary improvements in public safety under his watch helped reverse the "police are irrelevant" narrative.

Colleagues in public health often appear to share the pre-Bratton viewpoint. They began researching gun violence prevention in the 1980s and from the beginning asserted that gun violence was a "public health problem" and could best be addressed through the methods and perspectives of their field. They (with notable exceptions) have ignored or minimized the role of the criminal justice system.[3] In the public health perspective, violence prevention requires working as far up the causal chain as possible, which leads back to "root causes." Law enforcement is viewed as responding to crime after it occurs, rather than seeking to prevent it, and hence of marginal interest. But that reflects a profound misunderstanding. In fact, the primary reason why police investigate crimes and arrest perpetrators is to prevent future crimes.

Sir Robert Peel, the father of British policing (hence the nickname "bobbies"), is credited with nine principles formulated in 1829 to guide the new police force. His first principle is the following: "The basic mission for which the police exist is to prevent crime and disorder."[4] The two principal mechanisms by which reactive policing can prevent crime are *deterrence* and *incapacitation*. Some individuals may be deterred from shooting another person during a robbery, gang dispute, or domestic argument by the perceived threat of arrest and punishment. If shooters are routinely convicted and imprisoned, that threat will have reality and be transmitted more effectively to the relevant individuals (members of violent gangs and other high-risk individuals). And if the police are successful in solving a shooting crime, locking up the shooter will prevent him from continuing his violent career. Arrests and convictions may also serve to interrupt retaliatory violence. Violence begets violence, and violence interrupted prevents future violence.

Police prevent violence not only by arresting shooters but also by preempting shootings through a variety of proactive methods. Because most shootings take place outside the home, one important preemptive strategy has been to enforce regulations that limit gun carrying in city limits. That is not a new idea: In the 1880s cow-town marshals of the Wild West sought to enforce local bans on gun carrying in city limits, which famously led to "the shootout at the OK Corral" in Tombstone, Arizona. Although important for public safety, police actions to deter illegal carrying must be carefully focused to avoid violating individual rights. "Focus" is also a guiding principle for directing proactive police efforts in other domains, including developing effective interventions for calming volatile gang rivalries and cooling violent "hot spots" in the city.

Advocates for the public health perspective have been among the leading voices for gun control. Stringent regulation of guns is warranted, in this view, because without guns, violent encounters tend to be far less deadly. But although there is much to be said for regulating firearms, this approach has limited scope in the American context. The political tide has swept away much of the state and local regulations during the past 50 years. That process was accelerated by a U.S. Supreme Court ruling in 2008 that for the first time found a personal right to "keep and bear arms" in the Second Amendment. Gun sales surged throughout 2020, adding fuel to the fire created by civil unrest and a fraught presidential campaign. No regulation stood in the way, and both the Court and the current political reality are likely to preclude more stringent legislation. Federal and some state regulations remain in place and are helpful, but for the purpose of gun violence prevention, they cannot serve as an alternative to enforcement of criminal law. More than that, these existing regulations are only effective to the extent that they are enforced—bringing us back to the importance of the police in the prevention effort.

Just to be clear, we are entirely supportive of addressing the fundamental socioeconomic conditions that are associated with serious violence. Reversing systemic racism, growing economic inequality, and child poverty is in the public interest, regardless of

whether there is a direct connection to crime and violence. But we are confident that serious violence rates can change dramatically even without fundamental social change. Recent history proves the point. During the Great Crime Drop, from 1993 to 2014, the national homicide rate halved, led by reductions in gun violence. Yet this dramatic improvement in public safety was not the result of improvements in the usual list of root-cause conditions.[5] Indeed, during that same period, the distribution of income became even more unequal, racial disparities in education and employment remained distressingly large, and "safety net" antipoverty programs were no less deficient. Yet every large city became dramatically safer and the quality of life thereby improved. Low-income minority neighborhoods, where gun violence is concentrated, were the particular beneficiaries. Here is our bottom line: We are committed to pursuing an equitable and just society, and also committed to pursuing public safety. Progress on either goal is much to be desired. The two goals are related, but not quite in the way sometimes suggested by progressive rhetoric. A more economically just society is obviously desirable but not a prerequisite for a safer society. And creating a safer society would reduce one of the great and unjust disparities.

The unprecedented surge in gun violence in 2020 killed and injured tens of thousands more than in the previous year—and most of the victims were Black. Communities of color, whose elders were particularly hard hit by the coronavirus pandemic, found their youth targeted by this second outbreak. The consequences of the surge in violence for these communities that already had high rates of endemic violence have been dire. We do not offer any easy answers but can provide guidance on how to make the law enforcement more effective in preventing gun violence. Experience, and systematic evaluation of that experience, helps point the way.

Introducing Ourselves

What we have to offer in this book is based in part on our own research and experience, so allow us to introduce ourselves. We have been researching gun violence prevention for a long time—Philip Cook for 45 years and Anthony Braga for 30 years. Braga's career in particular has benefited from the willingness of some police chiefs to invite academics to participate in documenting and evaluating reform efforts, to run experiments, and even to help shape programs and policy. Early in his career, starting in late 1994, he worked at Harvard's Kennedy School of Government, where he and several colleagues were tasked with assisting the Boston Police Department in reversing the epidemic of gang violence in Boston. The program they developed and helped implement, known as Operation Ceasefire, was highly effective at reducing shootings and became a widely imitated model for other cities.

The best known element of Ceasefire was an innovation called focused deterrence, in which the Boston Police "called in" the members of a violent gang and warned them that they were all subject to enhanced enforcement if any members were known to be involved with guns. At the same time, street outreach workers and social service providers attending the call-in offered help in redirecting their lives. The community, and particularly Black churches, provided vital support to this dramatic intervention. A key conceptual insight was that youths caught up in drug dealing and gang violence were capable of making better choices, and they would do so if it appeared worthwhile. The possibility of arrest, always real, was made personal and hence more influential on that choice.

Braga's career of "action research" continued during his faculty appointments at Harvard, Rutgers, Northeastern, and now Penn. For example, in the City of Lowell, Massachusetts, he organized and ran a promising field experiment in which the police were coached to identify hot spots of crime and develop interventions that could help gain control by limiting crime opportunities at these problem places.

Between 2007 and 2013, he served as Chief Policy Advisor to former Boston Police Commissioner Edward F. Davis and worked with his command staff and line-level officers on community policing and crime prevention initiatives, including a series of reforms that were effective in reducing gun violence and increasing homicide clearance rates. When New York City settled a lawsuit challenging its "stop, question, and frisk" program to get guns off the street, Braga was appointed a member of the federal monitor team to oversee compliance, giving him a close-up view of the reforms implemented by the New York Police Department.

Cook has pursued a somewhat more conventional academic career path as a professor of public policy at Duke University. He was one of the first scholars of any discipline (he is an economist) to develop a research program in gun violence prevention. He and Braga met early in Braga's career, and they have worked together on a variety of projects ever since. In recent years, Cook has become convinced that the least developed area of gun violence research (relative to its potential payoff) has been policing, particularly research on how to increase the effectiveness of the police in solving gun assaults and murders. He is heading up a research team at the University of Chicago to understand the secular decline in homicide arrest rates (in Chicago and nationwide) and explore ways to reverse that trend. In one project, he is evaluating the Chicago Police Department Bureau of Detectives' new "technology centers" that facilitate the acquisition and use of video evidence in cases of serious violence.

So what the two of us have to offer is informed by both experience and research in the field. We are motivated by a shared belief that gun violence is a serious problem and that the police and criminal justice system must be an important part of the solution.

A Focus on Routine Violence

Our primary concern is with the violence associated with routine assaults and robberies. This sort of violence rarely gets the headlines. But it accounts for the vast majority of gun homicides and

nonfatal gunshot injuries each year nationwide, including more than 100,000 victims in 2020. The neighborhoods in which gun violence is concentrated suffer far-reaching consequences. First, the threat of violence drives away families who can afford to live elsewhere and discourages investment so that retail outlets and other employers are scarce. Those who do live there—children especially—are fearful, even traumatized, by the sounds of gunfire and by knowing people who have been shot, and daily activities are limited by the effort to avoid becoming a victim. Fortunately, these processes can be reversed, as evident in the renaissance in low-income neighborhoods in New York City and other large cities during the Great Crime Drop that began in 1993 and ended in 2014. Effective violence prevention is fundamental to community and economic development, mental health, and a decent quality of life. And prevention of this endemic violence is a matter of racial justice and basic fairness. More than 60% of victims nationwide are African American, and the impacted neighborhoods are predominantly minority and poor.

We are also concerned with shootings by law enforcement officers. Approximately 1,000 people each year are shot dead by officers on duty. Most, but not all, of these shootings are justified by the circumstances, in which the officer or someone else was being attacked or threatened. But a handful of well-documented cases in which the shooting is not justified and involves a Black victim have served to exacerbate distrust of the police. Many other cases may be legally justified could have been avoided with different tactics. Reducing the incidence of excessive use of force by police must be a priority in any plan to improve police effectiveness and to reduce the social costs of policing. The situation is not hopeless. Indeed, some departments are doing much better than others. Phoenix, Arizona, and Dallas, Texas, for example, are similar cities (commercial hubs, similar size and crime rate, lax gun controls, and large Hispanic population), but Phoenix has more than five times the per capita rate of fatal shootings by police compared to Dallas. The likely difference can be found in management practices by the police department.

Two other categories of gun violence are prominent in the national conversation about gun violence, although they are not our main focus here. First, mass shootings in schools and other public places account for less than 1% of gun-violence victims but have an outsize impact on our national well-being. Millions of schoolchildren have to undergo "active shooter" drills on a regular basis, ensuring that if they were not already scared, they will learn that they should be. The second category is political violence, a possibility that became vivid when a mob of White supremacists and other insurrectionists invaded the U.S. Capitol Building on January 6, 2021, seeking to block the transition from President Trump to President Biden. Although the mob did not use their guns on that occasion, we learn from their social media posts that many are heavily armed and pose an ongoing threat to public officials and institutions. Any plan to prevent mass shootings or armed insurrection requires a central role for law enforcement. But those tasks have little overlap with policing street violence and lie outside of our scope.

Policing Offenders

We focus on three general approaches to policing gun-violence offenders. The first is through proactive police activities targeted on high-violence areas of the city. That approach has been refined by the discovery of the surprising degree to which violence is concentrated with respect to both people and places. Focusing police resources on hot spots in the city accomplishes more than does random patrol. The advantage of a focused approach is illustrated by the history of "stop, question, and frisk" programs, which were intended to help get guns off the street. At the peak of New York City's program, young men in minority neighborhoods reported they could scarcely leave their residence without at least one confrontation with the police. In response to obvious problems of overreach, not to mention lawsuits, New York, Chicago, Los Angeles, and other cities backed off of this approach, becoming much more selective. A proactive program confined to hot spots, and directed at

known offenders, can be effective at much lower cost with respect to community relations. Such trade-offs must be respected in designing policy.

Targeted patrol of violent hot spots helps deter violence. Police can also play an active role in reducing the opportunity for violent crime in hot spots. Persistent concentrations of violent crime may be addressed by a variety of means: improving lighting, redirecting traffic, clearing vacant lots and empty structures, providing increased surveillance, enforcing liquor laws, and so forth. The police can serve an important role in identifying potential solutions to local problems and working with other city agencies and local business to have them adopted.

A second approach to gun violence prevention, also proactive, is to identify the most violent gangs—which in some cities account for a large portion of gun crime—and communicate to members a credible threat of legal consequences if they do not give up their guns. As mentioned above, Braga contributed to the design and implementation of the first such program, in Boston. It has been replicated in other jurisdictions. Many commentators have speculated that the threat of arrest has little effect and would have no leverage with gang members—after all, many of them already have long rap sheets and in any event have chosen to continue a life of street crime despite the considerable hazards associated with drug dealing and gang-related conflicts. But the evidence to the contrary is compelling. The success of Operation Ceasefire and similar programs not only suggests that such programs are worthwhile but also offers a more basic lesson: Contrary to the skeptics, some of these young men can indeed be swayed by a credible threat of future legal consequences for carrying and using guns in crime. That implication opens the door to other gun-violence interventions that rely on the deterrent effect of arrest and punishment. Importantly, focused deterrence programs include community mobilization and social service provision actions that help enhance police legitimacy in cities that have adopted the approach.

The third approach we consider is to increase the arrest and conviction rate for criminal shootings, both nonfatal and fatal.

Following Sir Robert Peel, the primary justification here is to prevent future violence. When an individual or a gang is violently attacked, the police represent an orderly and legitimate alternative to further violence in the quest for private revenge. A successful investigation resulting in a good arrest and prosecution is in effect a service to anyone who cares about the victim and the neighborhood, whereas a failed investigation may be viewed as the result of a lack of interest or effort by the police. Distressingly, failure is much more common than success. A number of large cities have arrest rates for nonfatal shootings on the order of 10%, and only a fraction of those result in conviction. If the victim dies, the chance of an arrest is higher, partly because the police give higher priority to homicide than nonfatal shootings—but even then the arrest rate is typically less than half. In a real sense, then, the police are underserving their constituency in this key respect. The police have been vilified for doing too much in minority communities (as in the case of high-volume street stops), but in cities in which one person can shoot another with what amounts to legal impunity, they are surely doing too little.

A common barrier to successful investigation is the lack of cooperative witnesses. In many cases, the victim of a nonfatal shooting knows something about the shooter that would be helpful to the investigation, which represents an opportunity—but only if the victim can be persuaded to talk. Indeed, if the victim refuses to cooperate, it is essentially impossible to make a case that would hold up in court. It would seem that if the victim dies, the investigator's challenge is still greater because a potentially key witness is lost. But the fact that gun homicides have a higher arrest rate than nonfatal shootings indicates that investigative effort (typically much higher for fatal shootings than nonfatal shootings) matters and can overcome obstacles to investigation, including reluctant witnesses. A lighter caseload for the detectives will lead to a higher arrest rate, as will improved access to technical support and better case management. There is much that can be done if law enforcement does assign higher priority to solving cases of serious violence. The goal is to ensure that shooters are held accountable and prevented from

shooting again. The ultimate goal is to serve the community by preventing gun violence.

Motivating the Police to Do the Right Thing

The much-discussed "Ferguson effect" is relevant to the role of police in violence prevention. It has become a familiar story. A Ferguson, Missouri, police officer fatally shot Michael Brown in August 2014. The event was videorecorded and widely publicized. The resulting demonstrations against the police resulted in police disengagement in some cities, including nearby St. Louis—not necessarily as a matter of departmental policy but, rather, as a matter of choice by individual patrol officers, who have a good deal of discretion on whether to make a stop or engage with people who pose a possible threat.[6] If officers stay in their cars and avoid trouble, the result could be to facilitate violent crime. As a well-documented case in point, the release of video showing the fatal police shooting of Laquan McDonald in Chicago was followed by a drop in monthly street stops by the Chicago Police Department from 60,000 to 10,000 (October 2015 to January 2016). Chicago suffered a 50% increase in homicides in 2016. Of course, there have been other such instances, and the victims have become household names. Most prominent is George Floyd, who died after being handcuffed and held down by a Minneapolis Police Department officer kneeling on his neck in May 2020. The encounter, captured on video, instigated large protests against police brutality in more than 150 U.S. cities. Again, there have been widespread reports of police disengagement and a reasonable supposition that this contributed to the surge of community violence in that year, which killed thousands nationwide.

Effective policing requires that the police *not* withdraw—that they be fully engaged, ready and willing to confront and challenge hostile, sometimes dangerous people even in neighborhoods where they are vilified. The way forward, in our view, is to have clear rules of

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CHAPTER XV
BERYCOIDEI

The Berycoid Fishes.—We may place in a separate order a group of fishes, mostly spiny-rayed, which appeared earlier in geological time than any other of the spinous forms, and which in several ways represent the transition from the isospondylous fishes to those of the type of the mackerel and perch. In the berycoid fishes the ventral fins are always thoracic, the number of rays almost always greater than I, 5, and in all cases an orbitosphenoid bone is developed in connection with the septum between the orbits above. This bone is found in the *Isospondyli* and other primitive fishes, but according to the investigations of Mr. E. C. Starks it is wanting in all percoid and scombroid forms, as well as in the *Haplomi* and in all the higher fishes. This trait may therefore, among thoracic fishes, be held to define the section or suborder of *Berycoidei*.

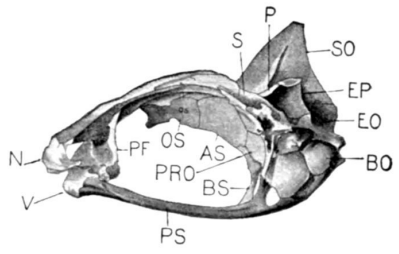

FIG. 198.—Skull of a Berycoid fish, *Beryx splendens* Cuv. & Val., showing the orbitosphenoid (OS),

These fishes, most primitive of the thoracic types, were more abundant in Cretaceous and Eocene times than now. The possession of an increased number of soft rays in the ventral fins is archaic, although in one family, the *Monocentridæ*, the number is reduced to three. Most of the living *Berycoidei* retain through life the archaic duct to the air-bladder characteristic of most abdominal or soft-rayed fishes. In some however, the duct is lost. For the first

characteristic of all Berycoid fishes.

time in the fish series the number of twenty-four vertebræ appears. In most spiny-rayed fishes of the tropics, of whatever family, this number is retained.

In every case spines are present in the dorsal fin, and in certain cases the development of the spinous dorsal surpasses that of the most extreme perch-like forms. In geological times the Berycoids preceded all other perch-like fishes. They are probably ancestral to all the latter. All the recent species, in spite of high specialization, retain some archaic characters.

The Alfonsinos: Berycidæ.—The typical family, *Berycidæ*, is composed of fishes of rather deep water, bright scarlet or black in color, with the body short and compressed, the scales varying in the different genera. The single dorsal fin has a few spines in front, and there are no barbels. The suborbitals are not greatly developed.

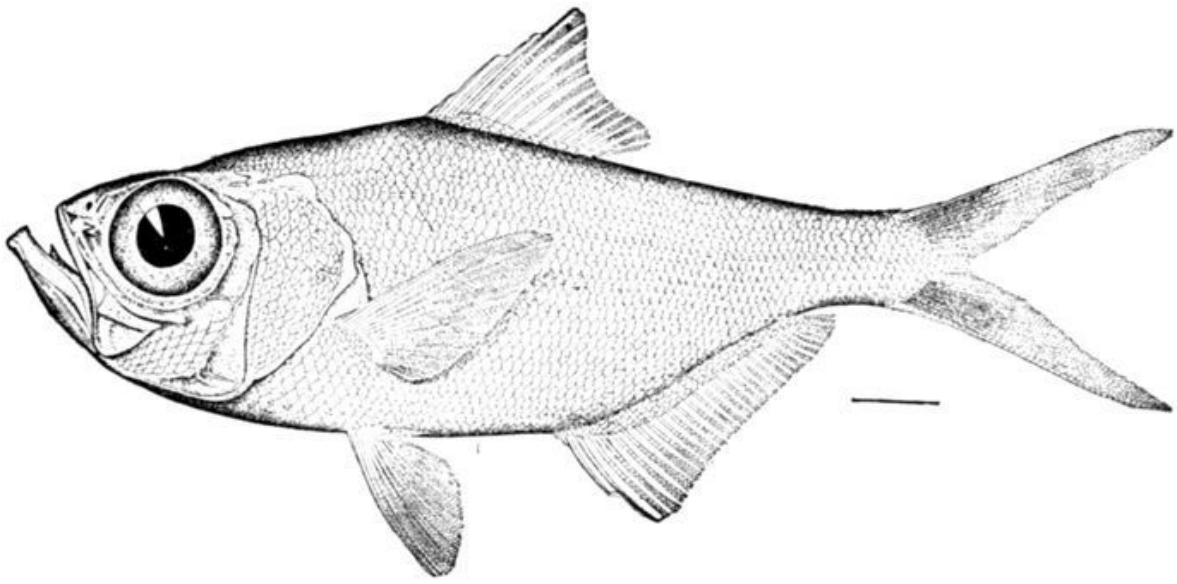

FIG. 199.—*Beryx splendens* Lowe. Gulf Stream.

The species of *Beryx*, called in Spanish *Alfonsino*, *Beryx elegans* and *Beryx decadactylus*, are widely distributed at moderate depths, the same species being recorded from Portugal, Madeira, Cuba, the Gulf

Stream, and Japan. The colors are very handsome, being scarlet with streaks of white or golden. These fishes reach the length of a foot or more and are valued as food where sufficiently common.

Numerous species of *Beryx* and closely allied genera are found in all rocks since Cretaceous times; *Beryx dalmaticus*, from the Cretaceous of Dalmatia, is perhaps the earliest. *Beryx insculptus* is found in New Jersey, but no other Berycoids are yet known as fossils from North America. *Sphenocephalus*, with four anal spines, is found in the chalk, as are also species of *Acrogaster* and *Pycnosterinx*, these being the earliest of fishes with distinctly spiny fins.

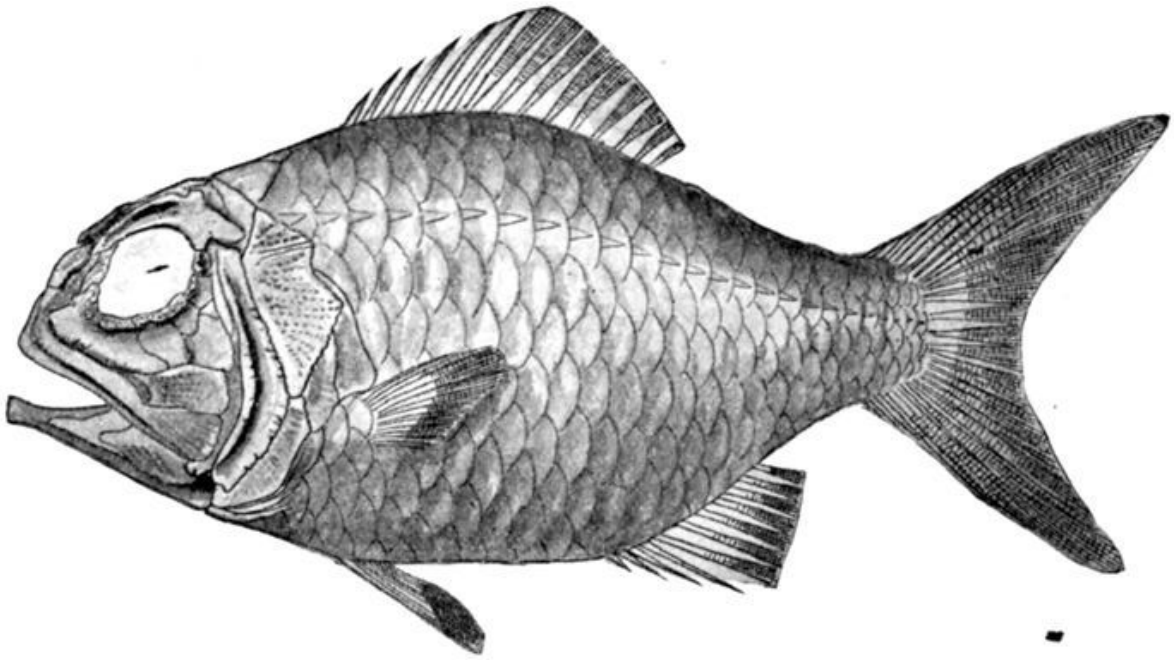

FIG. 200.—*Hoplopteryx lewesiensis* (Mantell), restored. English Cretaceous Family *Berycidæ*. (After Woodward.)

The *Trachichthyidæ* are deep-sea fishes with short bodies, cavernous skulls, and rough scales. The dorsal is short, with a few spines in front. The suborbitals are very broad, often covering the cheeks, and the anal fin is shorter than the dorsal, a character which separates these fishes from the *Berycidæ*, in which group the anal fin is very

long. The belly has often a serrated edge, and the coloration is red or black, the black species being softer in body and living in deeper water. Species of *Hoplostethus*, notably *Hoplostethus mediterraneus*, are found in most seas at a considerable depth. *Trachichthys*, a genus scarcely distinguishable from *Hoplostethus*, is found in various seas. The genus *Paratrachichthys* is remarkable for the anterior position of the vent, much as in *Aphredoderus*. Species occur in Japan and Australia. *Gephyroberyx*, with the dorsal fin notched, is known from Japan (*G. japonicus*) and Madeira (*G. darwini*).

We may also refer to the *Trachichthyidæ* certain species of still deeper waters, black in color and still softer in texture, with smaller scales which are often peculiar in form. These constitute the genera *Caulolepis*, *Anoplogaster*, *Melamphaës*, and *Plectromus*. In *Caulolepis* the jaws are armed with very strong canines.

Allied to the *Trachichthyidæ* are also the fossil genera *Hoplopteryx* and *Homonotus*. *Hoplopteryx lewesiensis*, from the English chalk, is one of the earliest of the spiny-rayed fishes.

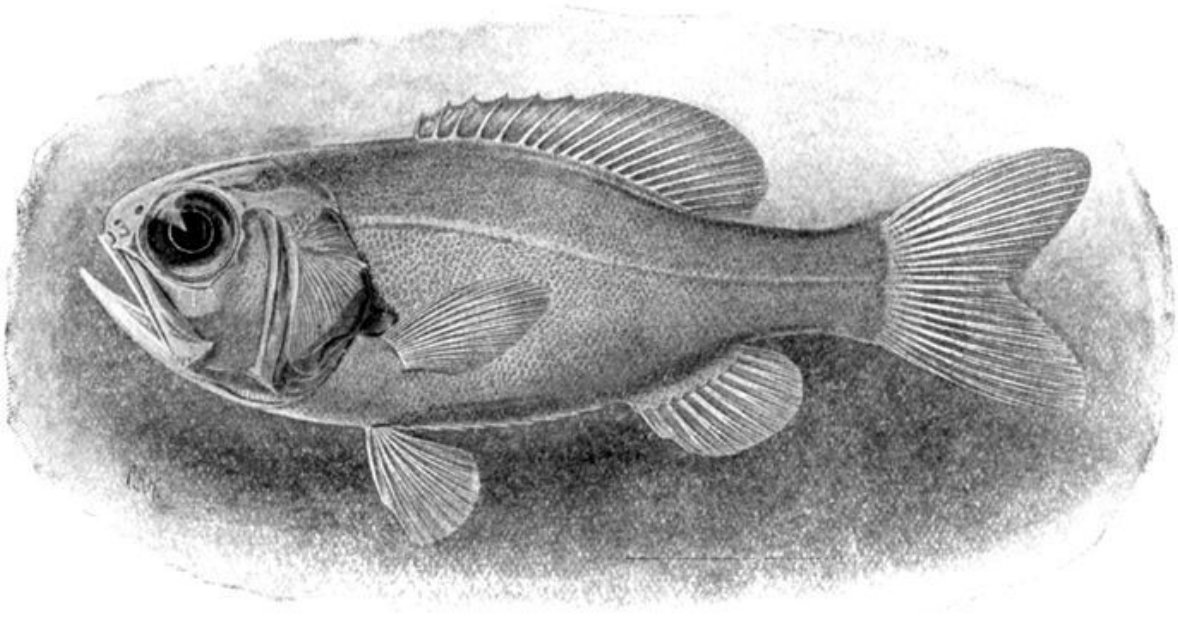

FIG. 201.—*Paratrachichthys prosthemius* Jordan & Fowler, Misaki, Japan. Family *Trachichthyidæ*.

The Soldier-fishes: Holocentridæ.—The soldier-fishes (*Holocentridæ*), also known as squirrel-fishes, Welshmen, soldados, matajuelos, malau, alehi, etc., are shore fishes very characteristic of rocky banks in the tropical seas. In this family the flesh is firm and the large scales very hard and with very rough edges. There are eleven spines in the dorsal and four in the anal, the third being usually very long. The ventral fins have one spine and seven soft rays. The whole head and body are rough with prickles. The coloration is always brilliant, the ground hue being scarlet or crimson, often with lines or stripes of white, black, or golden. The fishes are valued as food, and they furnish a large part of the beauty of coloration so characteristic of the fishes of the coral reefs. The species are active, pugnacious, carnivorous, but not especially voracious, the mouth being usually small.

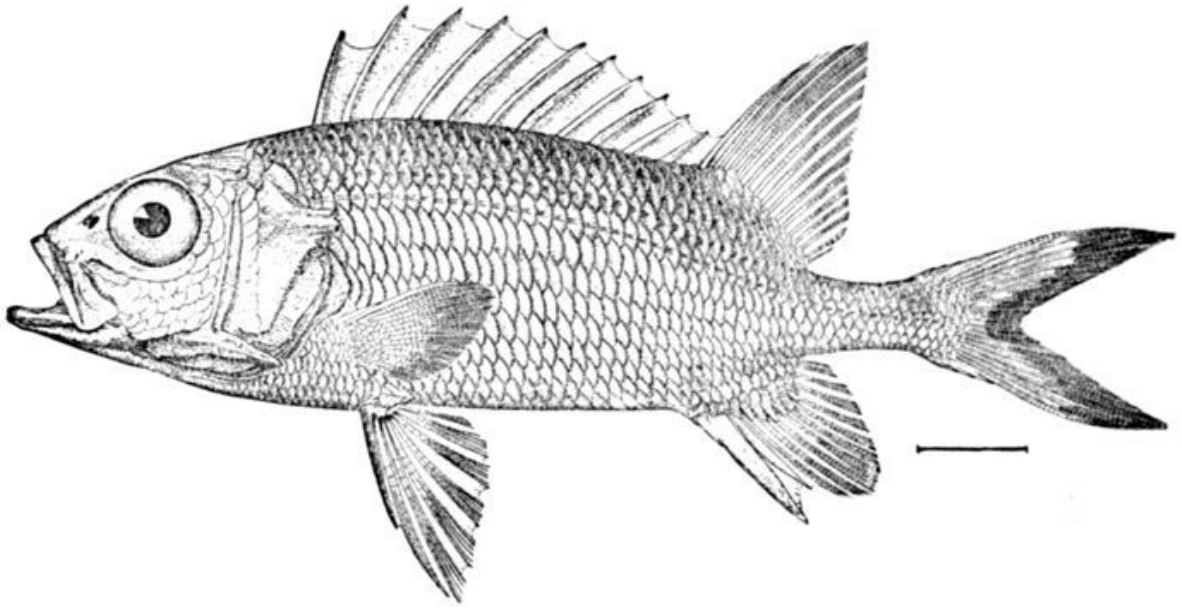

FIG. 202.—Soldier-fish, *Holocentrus ascenscionis* (Osbeck).

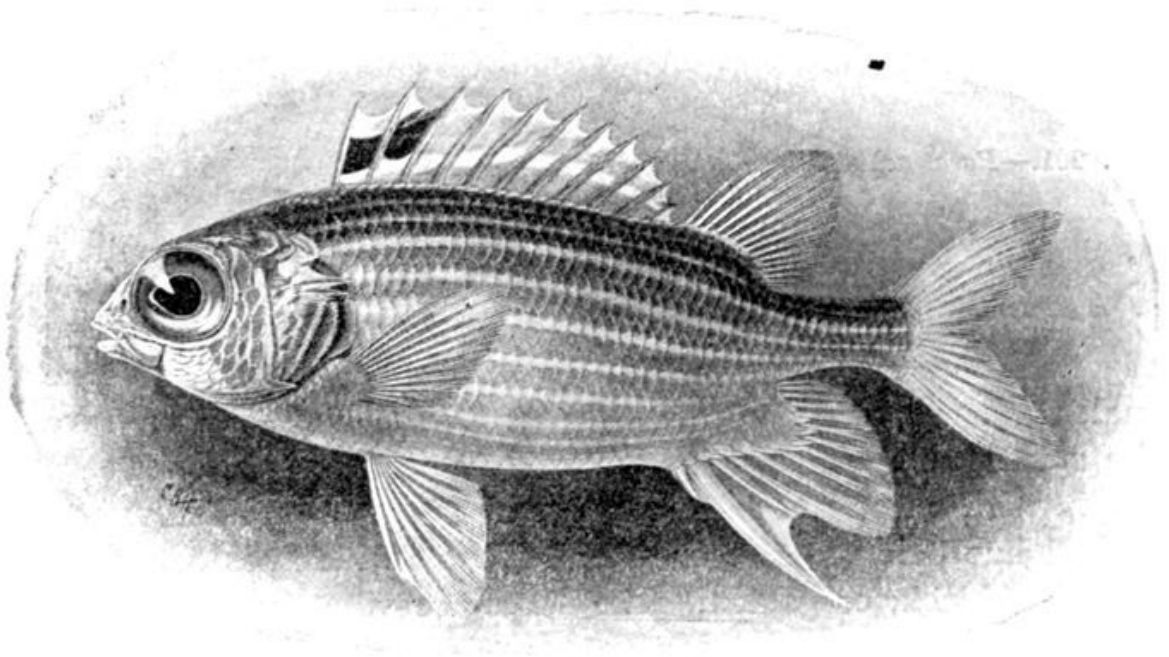

FIG. 203.—Soldier-fish, *Holocentrus ittodai* Jordan & Fowler. Riu Kiu Islands, Japan.

The genus *Holocentrus* is characterized by the presence of a large spine on the angle of the preopercle. Its species are especially numerous, *Holocentrus ascenscionis*, abundant in Cuba, ranges northward in the Gulf Stream. *Holocentrus suborbitalis*, the mojarra cardenal, is a small, relatively dull species swarming about the rocks of western Mexico. *Holocentrus spinosissimus* is a characteristic fish of Japan. Many other species abound throughout Polynesia and the East Indies, as well as in tropical America. *Holocentrus ruber* and *Holocentrus diadema* are common species of Polynesia and the East Indies. Other abundant species are *H. spinifer*, *H. microstomus*, and *H. violascens*.

Holocentrus marianus is the marian of the French West Indies. *Holocentrus sammara*, and related large-mouthed species occur in Polynesia.

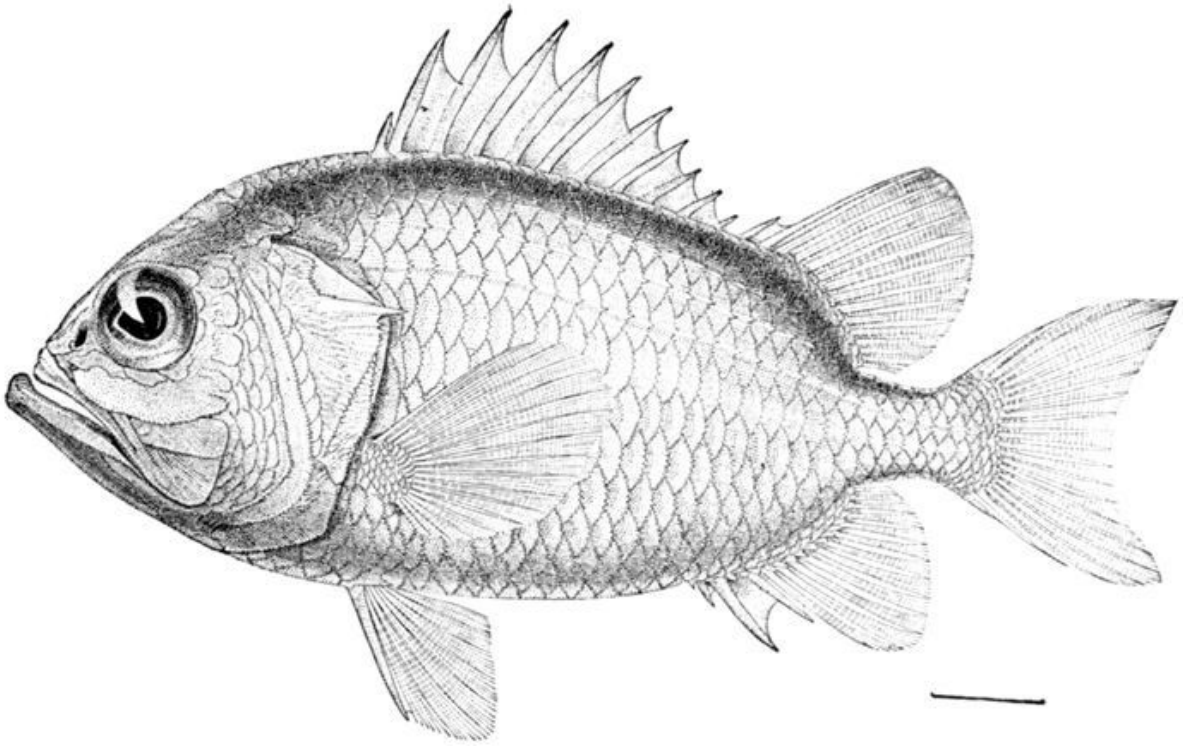

FIG. 204.—*Ostichthys japonicus* (Cuv. & Val.). Giran, Formosa.

In *Myripristis* the preopercular spine is wanting and the air-bladder is divided into two parts, the anterior extending to the ear. *Myripristis jacobus* is the brilliantly colored candil, or "Frère Jacques," of the West Indies. Species of *Myripristis* are known in Hawaii as *u-u*. A curious method of catching *Myripristis murdjan* is pursued on the Island of Hawaii. A living fish is suspended by a cord in front of a reef inhabited by this species. It remains with scarlet fins spread and glistening red scales. Its presence is a challenge to other individuals, who rush out to attack it. These are then drawn out by a concealed scoop-net, and a fresh specimen is taken as a decoy. *Myripristis pralinius*, *M. multiradiatus*, and other species occur in Polynesia. *Ostichthys* is allied to *Myripristis* but with very large rough scales. *Ostichthys japonicus* is a large and showy fish of the waters of Japan. *Ostichthys pillwaxi* occurs at Honolulu. *Holotrachys lima* is a small, brick-red fish with small very rough scales found throughout Polynesia.

Fossil species of *Holocentrus*, *Myripristis*, and related extinct genera occur in the Eocene and Miocene. *Holocentrus macrocephalus*, from Monte Bolca Eocene, is one of the best known. *Myricanthus leptacanthus* from the same region, has very slender spines in the fins.

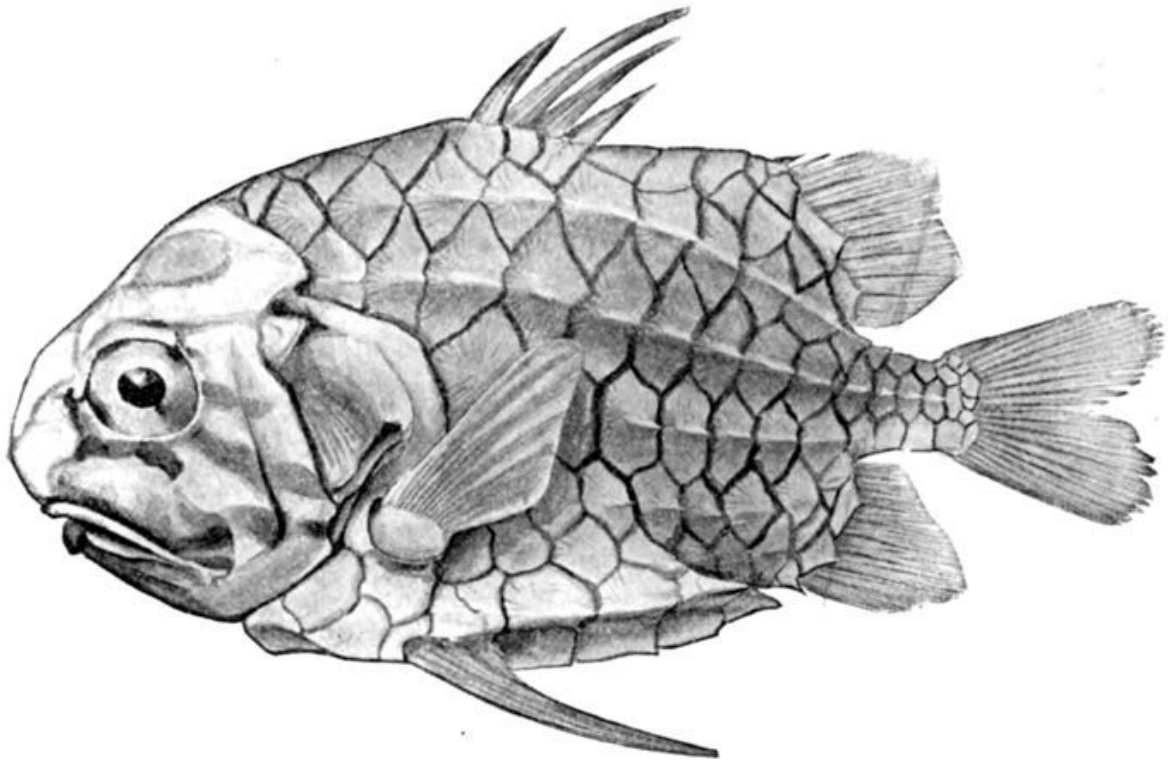

FIG. 205.—Pine-cone Fish, *Monocentris japonicus* (Houttuyn). Waka, Japan.

The Polymixiidæ.—The family of *Polymixiidæ*, or barbudos, is one of the most interesting in Ichthyology from its bewildering combination of characters belonging to different groups. With the general aspect of a Berycoid, the ventral rays I, 7, and the single dorsal fin with a few spines, *Polymixia* has the scales rather smooth and at the chin are two long barbels which look remarkably like those of the family of *Mullidæ* or *Surmullets*. As in the *Mullidæ*, there are but four branchiostegals. In other regards the two groups seem to have little in common. According to Starks, the specialized feelers

at the chin are different in structure and must have been independently developed in the two groups. In *Polymixia*, each barbel is suspended from the hypohyal; three rudimentary branchiostegals forming its thickened base. In *Mullus*, each barbel is suspended from the trip of a slender projection of the ceratohyal, having no connection with the branchiostegals. *Polymixia* possesses the orbitosphenoid bone and is a true berycoid, while the *Mullidæ* are genuine percoid fishes.

Four species of *Polymixia* are recorded from rather deep water: *Polymixia nobilis* from Madeira, *Polymixia lowei* from the West Indies, *Polymixia berndti* from Hawaii, and *Polymixia japonica* from Japan. All are plainly colored, without red.

The Pine-cone Fishes: Monocentridæ.—Among the most extraordinary of all fishes is the little family of *Monocentridæ*, or pine-cone fishes. *Monocentris japonicus*, the best-known species, is common on the coasts of Japan. It reaches the length of five inches. The body is covered with a coat of mail, made of rough plates which look as though carelessly put together. The dorsal spines are very strong, and each ventral fin is replaced by a very strong rough spine. The animal fully justifies the remark of its discoverer, Houttuyn (1782), that it is "the most remarkable fish which exists." It is dull golden brown in color, and in movement as sluggish as a trunkfish. A similar species, called knightfish, *Monocentris gloriæ-maris*, is found in Australia. No fossils allied to *Monocentris* are known.

CHAPTER XVI
PERCOMORPHI

UBORDER Percomorphi, the Mackerels and Perches.—We may place in a single suborder the various groups of fishes which cluster about the perches, and the mackerels. The group is not easily definable and may contain heterogeneous elements. We may, however, arrange in it, for our present purposes, those spiny-rayed fishes having the ventral fins thoracic, of one spine and five rays (the ventral fin occasionally wanting or defective, having a reduced number of rays), the lower pharyngeal bones separate, the suborbital chain without backward extension or bony stay, the post-temporal normally developed and separate from the cranium, the premaxillary and maxillary distinct, the cranium itself without orbitosphenoid bone, having a structure not greatly unlike that of perch or mackerel, and the back-bone primitively of twenty-four vertebræ, the number increased in arctic, pelagic, or fresh-water offshoots.

The species, comprising the great body of the spiny-rayed forms, group themselves chiefly about two central families, the *Scombridæ*, or mackerels, and the *Serranidæ*, the sea-bass, with their fresh-water allies, the *Percidæ*, or perch.

The Mackerel Tribe: Scombroidea.—The two groups of *Percomorphi*, the mackerel-like and the perch-like, admit of no exact definition, as the one fully grades into the other. The mackerel-like forms, or *Scombroidea*, as a whole are defined by their adaptation for swift movement. The profile is sharp anteriorly, the tail slender,

with widely forked caudal; the scales are usually small, thin, and smooth, of such a character as not to produce friction in the water.

In general the external surface is smooth, the skeleton light and strong, the muscles firm, and the species are carnivorous and predaceous. But among the multitude of forms are many variations, and some of these will seem to be exceptions to any definition of mackerel-like fishes which could possibly be framed.

The mackerels, or *Scombroidea*, have usually the tail very slender, composed of very strong bones, with widely forked fin. In the perch and bass the tail is stout, composed largely of flesh, the supporting vertebræ relatively small and spread out fan-fashion behind. Neither mackerels nor perch nor any of their near allies ever have more than five soft rays in the ventral fins, and the persistence of this number throughout the *Percomorphi*, *Squamipinnes*, *Pharyngognathi*, and spiny fishes generally must be attributed to inheritance from the primitive perch-like or mackerel-like forms. In almost all the groups to be considered in this work, after the *Berycoidea* the ventral rays are I, 5, or else fewer through degeneration, never more. In the central or primitive members of most of these groups there are twenty-four vertebræ, the number increased in certain forms, probably through repetitive degeneration.

The True Mackerels: Scombridæ.—We may first consider the great central family of *Scombridæ*, or true mackerels, distinguished among related families by their swift forms, smooth scales, metallic coloration, and technically by the presence of a number of detached finlets behind the dorsal and anal fins. The cut of the mouth is peculiar, the spines in the fins are feeble, the muscular system is extremely strong, the flesh oily, and the air-bladder reduced in size or altogether wanting. As in most swift-swimming fishes and fishes of pelagic habit, the vertebræ are numerous and relatively small, an arrangement which promotes flexibility of body. It is not likely that this group is the most primitive of the scombroid fishes. In some respects the *Stromateidæ* stand nearer the primitive stock. The true

mackerels, however, furnish the most convenient point of departure in reviewing the great group.

In the genus of true mackerels, *Scomber*, the dorsal fins are well separated, the first being rather short, and the scales of the shoulders are not modified to form a corselet. There are numerous species, two of them of general interest. The common mackerel, *Scomber scombrus*, is one of the best known of food-fishes. It is probably confined to the Atlantic, where on both shores it runs in vast schools, the movements varying greatly from season to season, the preference being for cool waters. The female mackerel produces about 500,000 eggs each year, according to Professor Goode. These are very minute and each is provided with an oil-globule, which causes it to float on the surface. About 400,000 barrels of mackerel are salted yearly by the mackerel fleet of Massachusetts. Single schools of mackerel, estimated to contain a million barrels, have been recorded. Captain Harding describes such a school as "a windrow of fish half a mile wide and twenty miles long."

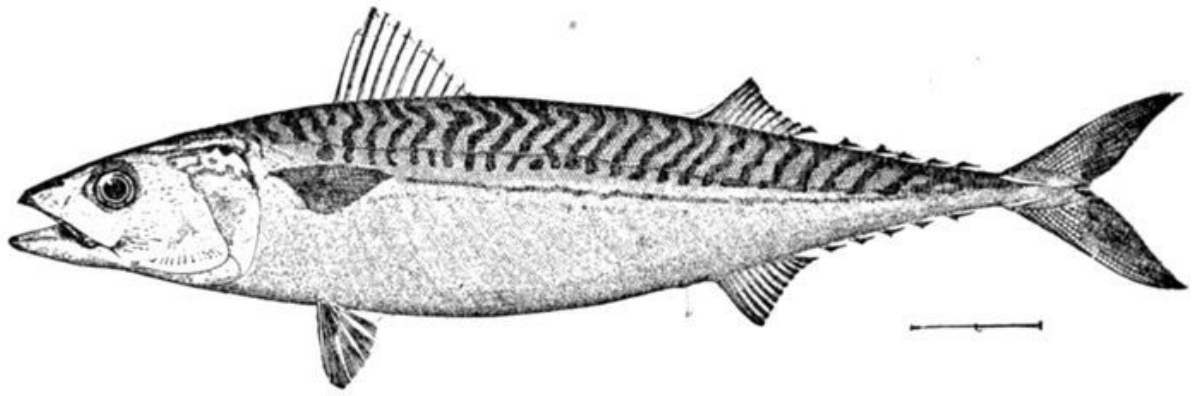

FIG. 206.—Mackerel, *Scomber scombrus* L. New York.

Professor Goode writes:

"Upon the abundance of mackerel depends the welfare of many thousands of the citizens of Massachusetts and Maine. The success of the mackerel-fishery is much more uncertain than that of the cod-

fishery, for instance, for the supply of cod is quite uniform from year to year. The prospects of each season are eagerly discussed from week to week in thousands of little circles along the coast, and are chronicled by the local press. The story of each successful trip is passed from mouth to mouth, and is a matter of general congratulation in each fishing community. A review of the results of the American mackerel-fishery, and of the movements of the fish in each part of the season, would be an important contribution to the literature of the American fisheries.

"The mackerel-fishery is peculiarly American, and its history is full of romance. There are no finer vessels afloat than the American mackerel-schooners—yachts of great speed and unsurpassed for seaworthiness. The modern instruments of capture are marvels of inventive skill, and require the highest degree of energy and intelligence on the part of the fishermen. The crews of the mackerel-schooners are still for the most part Americans of the old colonial stock, although the cod and halibut fisheries are to a great extent given up to foreigners.

"When the mackerel is caught, trout, bass, and sheepshead cannot vanquish him in a gastronomic tournament. In Holland, to be sure, the mackerel is not prized, and is accused of tasting like rancid fish-oil, and in England, even, they are usually lean and dry, like the wretched skeletons which are brought to market in April and May by the southern fleet, which goes forth in the early spring from Massachusetts to intercept the schools as they approach the coasts of Carolina and Virginia. They are not worthy of the name of mackerel. *Scomber Scombrus* is not properly in season until the spawning time is over, when the schools begin to feed at the surface in the Gulf of Maine and the 'North Bay.'

"Just from the water, fat enough to broil in its own drippings, or slightly corned in strong brine, caught at night and eaten in the morning, a mackerel or a bluefish is unsurpassable. A well-cured autumn mackerel is perhaps the finest of all salted fish, but in these days of wholesale capture by the purse-seine, hasty dressing and

careless handling, it is very difficult to obtain a sweet and sound salt mackerel. Salt mackerel may be boiled as well as broiled, and a fresh mackerel may be cooked in the same manner. Americans will usually prefer to do without the sauce of fennel and gooseberry which transatlantic cooks recommend. Fresh and salt, fat and lean, new or stale, mackerel are consumed by Americans in immense quantities, as the statistics show, and whatever their state, always find ready sale."

Smaller, less important, less useful, but far more widely distributed is the chub-mackerel, or thimble-eyed mackerel, *Scomber japonicus* (Houttuyn, 1782), usually known by the later name of *Scomber colias* (Gmelin, 1788). In this species the air-bladder (absent in the common mackerel) is moderately developed. It very much resembles the true mackerel, but is of smaller size, less excellence as a food-fish, and keeps nearer to the shore. It may be usually distinguished by the presence of vague, dull-gray spots on the sides, where the true mackerel is lustrous silvery.

This fish is common in the Mediterranean, along our Atlantic coast, on the coast of California, and everywhere in Japan.

Scomber antarcticus is the familiar mackerel of Australia. *Scomber loo*, silvery, with round black spots, is the common mackerel of the South Seas, locally known as *Ga*.

Scomber priscus is a fossil mackerel from the Eocene.

Auxis thazard, the frigate mackerel, has the scales of the shoulders enlarged and somewhat coalescent, forming what is called a corselet. The species ranges widely through the seas of the world in great numbers, but very erratic, sometimes myriads reaching our Eastern coast, then none seen for years. It is more constant in its visits to Japan and Hawaii. Fossil species of *Auxis* are found in the Miocene.

The genus *Gymnosarda* has the corselet as in *Auxis*, but the first dorsal fin is long, extending backward to the base of the second. Its two species, *Gymnosarda pelamis*, the Oceanic bonito, and

Gymnosarda alleterata, the little tunny, are found in all warm seas, being especially abundant in the Mediterranean, about Hawaii and Japan. These are plump fish of moderate size, with very red and very oily flesh.

Closely related to these is the great tunny, or Tuna (*Thunnus thynnus*) found in all warm seas and reaching at times a weight of 1500 pounds. These enormous fishes are much valued by anglers, a popular "Tuna Club" devoted to the sport of catching them with a hook having its headquarters at Avalon, on Santa Catalina Island, in California. They are good food, although the flesh of the large ones is very oily. The name horse-mackerel is often given to these monsters on the New England coast. In California, the Spanish name of tuna has become current among fisherman.

Very similar to the tuna, but much smaller, is the Albacore (*Germo alalonga*). This reaches a weight of fifteen to thirty pounds, and is known by its very long, almost ribbon-like pectoral fins. This species is common in the Mediterranean, and about the Santa Barbara Islands, where it runs in great schools in March. The flesh of the albacore is of little value, unless, as in Japan, it is eaten raw. The Japanese shibi (*Germo germo*) is another large albacore, having the finlets bright yellow. It is found also at Hawaii.

The bonito (*Sarda sarda*) wanders far throughout the Atlantic, abounding on our Atlantic coast as in the Mediterranean, coming inshore in summer to spawn or feed. Its flesh is red and not very delicate, though it may be reckoned as a fair food-fish. It is often served under the name of "Spanish mackerel" to the injury of the reputation of the better fish.

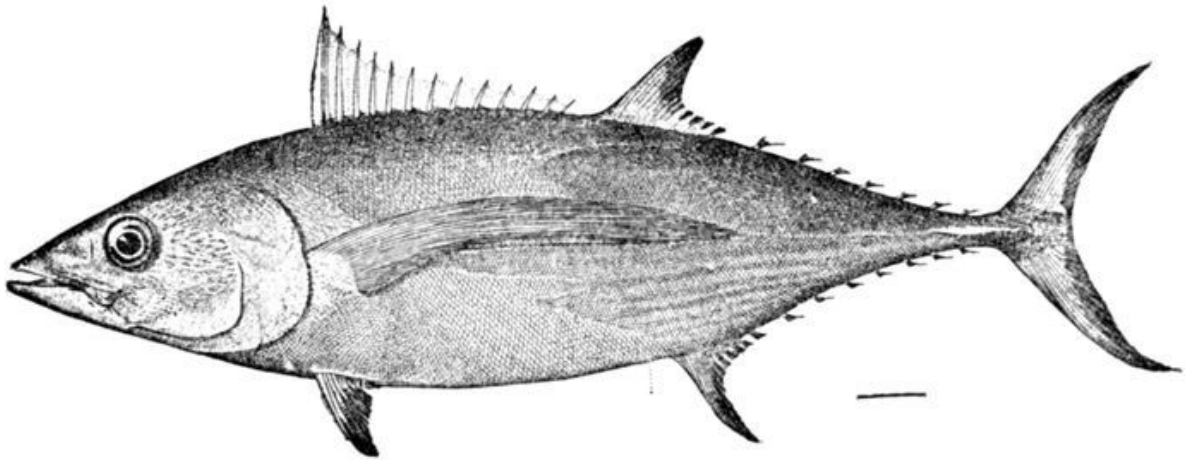

FIG. 207.—The Long-fin Albacore, *Germo alalunga* (Gmelin). Gulf Stream.

Professor Goode writes:

"One of these fishes is a marvel of beauty and strength. Every line in its contour is suggestive of swift motion. The head is shaped like a minie bullet, the jaws fit together so tightly that a knife-edge could scarcely pass between, the eyes are hard, smooth, their surfaces on a perfect level with the adjoining surfaces. The shoulders are heavy and strong, the contours of the powerful masses of muscle gently and evenly merging into the straighter lines in which the contour of the body slopes back to the tail. The dorsal fin is placed in a groove into which it is received, like the blade of a clasp-knife in its handle. The pectoral and ventral fins also fit into depressions in the sides of the fish. Above and below, on the posterior third of the body, are placed the little finlets, each a little rudder with independent motions of its own, by which the course of the fish may be readily steered. The tail itself is a crescent-shaped oar, without flesh, almost without scales, composed of bundles of rays flexible, yet almost as hard as ivory. A single sweep of this powerful oar doubtless suffices to propel the bonito a hundred yards, for the polished surfaces of its body can offer little resistance to the water. I have seen a common dolphin swimming round and round a steamship, advancing at the rate of twelve knots an hour, the effort being hardly perceptible. The wild

duck is said to fly seventy miles in an hour. Who can calculate the speed of the bonito? It might be done by the aid of the electrical contrivances by which is calculated the initial velocity of a projectile. The bonitoes in our sounds to-day may have been passing Cape Colony or the Land of Fire day before yesterday."

Another bonito, *Sarda chilensis*, is common in California; in Chile, and in Japan. This species has fewer dorsal spines than the bonito of the Atlantic, but the same size, coloration, and flesh. Both are blue, with undulating black stripes along the side of the back.

The genus *Scomberomorus* includes mackerels slenderer in form, with larger teeth, no corselet, and the flesh comparatively pale and free from oil.

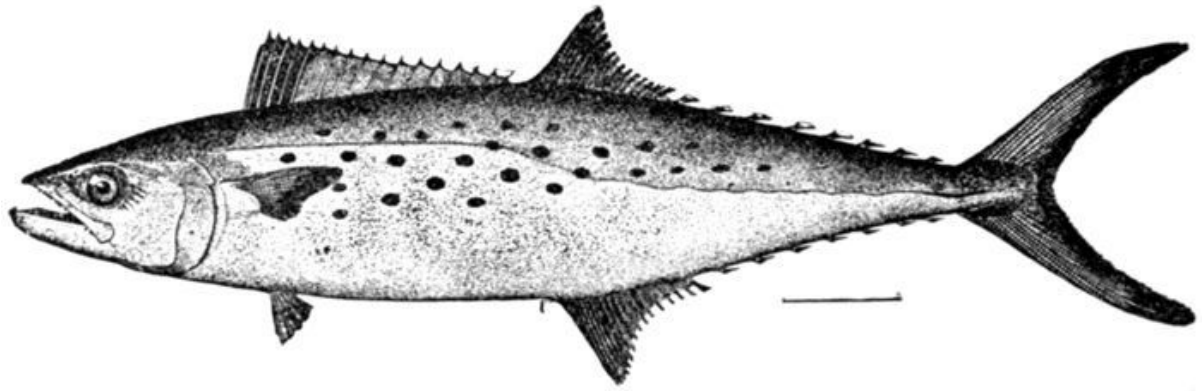

FIG. 208.—The Spanish Mackerel, *Scomberomorus maculatus* (Mitchill). New York.

Scomberomorus maculatus, the Spanish mackerel of the West Indies, is one of the noblest of food-fishes. Its biography was written by Mitchill almost a century ago in these words:

"A fine and beautiful fish; comes in July."

Goode thus writes of it:

"The Spanish mackerel is surely one of the most graceful of fishes. It appeals as scarcely any other can to our love of beauty, when we

look upon it, as shown in Kilbourn's well-known painting, darting like an arrow just shot from the bow, its burnished sides, silver flecked with gold, thrown into bold relief by the cool green background of the rippled sea; the transparent grays, opalescent whites, and glossy blacks of its trembling fins enhance the metallic splendor of its body, until it seems to rival the most brilliant of tropical birds. Kilbourn made copies of his large painting on the pearly linings of seashells and produced some wonderful effects by allowing the natural luster of the mother-of-pearl to show through his transparent pigments and simulate the brilliancy of the life-inspired hues of the quivering, darting sea-sprite, whose charms even his potent brush could not properly depict.

"It is a lover of the sun, a fish of tropical nature, which comes to us only in midsummer, and which disappears with the approach of cold, to some region not yet explored by ichthyologists. It is doubtless very familiar in winter to the inhabitants of some region adjacent to the waters of the Caribbean or the tropical Atlantic, but until this place shall have been discovered it is more satisfactory to suppose that with the bluefish and the mackerel it inhabits that hypothetical winter resort to which we send the migratory fishes whose habits we do not understand—the middle strata of the ocean, the floating beds of Sargassum, which drift hither and thither under the alternate promptings of the Gulf-stream currents and the winter winds."

The Spanish mackerel swims at the surface in moderate schools and is caught in abundance from Cape May southward. Its white flesh is most delicious, when properly grilled, and Spanish mackerel, like pampano, should be cooked in no other way.

A very similar species, *Scomberomorus sierra*, occurs on the west coast of Mexico. For some reason it is little valued as food by the Mexicans. In California, the Monterey Spanish mackerel (*Scomberomorus concolor*) is equally excellent as a food-fish. This fish lacks the spots characteristic of most of its relatives. It was first found in the Bay of Monterey, especially at Santa Cruz and Soquel, in abundance in the autumn of 1879 and 1880. It has not, so far as is

known, been seen since, nor is the species recorded from any other coast.

The true Spanish mackerel has round, bronze-black spots upon its sides. Almost exactly like it in appearance is the pintado, or sierra (*Scomberomorus regalis*), but in this species the spots are oblong in form. The pintado abounds in the West Indies. Its flesh is less delicate than that of the more true Spanish mackerel. The name *sierra*, saw, commonly applied to these fishes by Spanish-speaking people, has been corrupted into *cero* in some books on angling.

Still other Spanish mackerel of several species occur on the coasts of India, Chile, and Japan.

The great kingfish, or cavalla (*Scomberomorus cavalla*), is a huge Spanish mackerel of Cuba and the West Indies, reaching a weight of 100 pounds. It is dark iron-gray in color, one of the best of food-fishes, and is unspotted, and its firm, rich flesh resembles that of the barracuda.

Still larger is the great guahu, or peto, an immense sharp-nosed, swift-swimming mackerel found in the East and West Indies, as well as in Polynesia, reaching a length of six feet and a weight of more than a hundred pounds. Its large knife-like teeth are serrated on the edge and the color is almost black. *Acanthocybium solandri* is the species found in Hawaii and Japan. The American *Acanthocybium petus*, occasionally also taken in the Mediterranean, may be the same species.

Fossil Spanish mackerels, tunnies, and albacores, as well as representatives of related genera now extinct, abound in the Eocene and Miocene, especially in northern Italy. Among them are *Scomber antiquus* from the Miocene, *Scombrinus macropomus* from the Eocene London clays, much like *Scomber*, but with stronger teeth, *Sphyrænodus priscus* from the same deposits, the teeth still larger, *Scombramphodon crossidens*, from the same deposits, also with strong teeth, like those of *Scomberomorus*. *Scomberomorus* is the best represented of all the genera as fossil, *Scomberomorus*

speciosus and numerous other species occurring in the Eocene. A fossil species of *Germo*, *G. lanceolatus*, occurs at Monte Bolca in Eocene rocks. Another tunny, with very small teeth is *Eothynnus salmonens*, from the lower Eocene near London. Several other tunny-like fishes occur in the lower Tertiary.

The Escolars: Gempylidæ.—More predaceous than the mackerels and tunnies are the pelagic mackerels, *Gempylidæ*, known as *escolars* ("scholars"), with the body almost band-shaped and the teeth very large and sharp. Some of these, from the ocean depths, are violet-black in color, those near the surface being silvery. *Escolar violaceus* lives in the abysses of the Gulf Stream. *Ruvettus pretiosus*, the black escolar, lives in more moderate depths and is often taken in Cuba, Madeira, Hawaii, and Japan. It is a very large fish, black, with very rough scales. The flesh is white, soft, and full of oil; sometimes rated very high, and at other times too rank to be edible. The name *escolar* means *scholar* in Spanish, but its root meaning, as applied to this fish, comes from a word meaning *to scour*, in allusion to the very rough scales.

Promethichthys prometheus, the rabbit-fish, or conejo, so-called from its wariness, is caught in the same regions, being especially common about Madeira and Hawaii. *Gempylus serpens*, the snake-mackerel, is a still slenderer and more voracious fish of the open seas. *Thyrsites atun* is the Australian "barracuda," a valued food-fish, voracious and predaceous.

Scabbard-and Cutlass-fishes: Lepidopidæ and Trichiuridæ.—The family of *Lepidopidæ*, or scabbard-fishes, includes degenerate mackerels, band-shaped, with continuous dorsal fin, and the long jaws armed with very small teeth. These are found in the open sea, *Lepidopus candatus* being the most common. This species reaches a length of five or six feet and comes to different coasts occasionally to deposit its spawn. It lives in warm water and is at once chilled by the least cold; hence the name of frostfish occasionally applied to it. Several species of *Lepidopus* are fossil in the later Tertiary. *Lepidopus glarisianus* occurs in the Swiss Oligocene, and with it

Thyrsitocephalus alpinus, which approaches more nearly to the *Gempylidæ*.

Still more degenerate are the *Trichiuridæ*, or cutlass-fishes, in which the caudal fin is wanting, the tail ending in a hair-like filament. The species are bright silvery in color, very slender, and very voracious, reaching a length of three to five feet. *Trichiurus lepturus* is rather common on our Atlantic coast. The names hairfish and silver-eel, among others, are often given to it. *Trichiurus japonicas*, a very similar species, is common in Japan, and other species inhabit the tropical seas. *Trichiurichthys*, a fossil genus with well-developed scales, precedes *Trichiurus* in the Miocene.

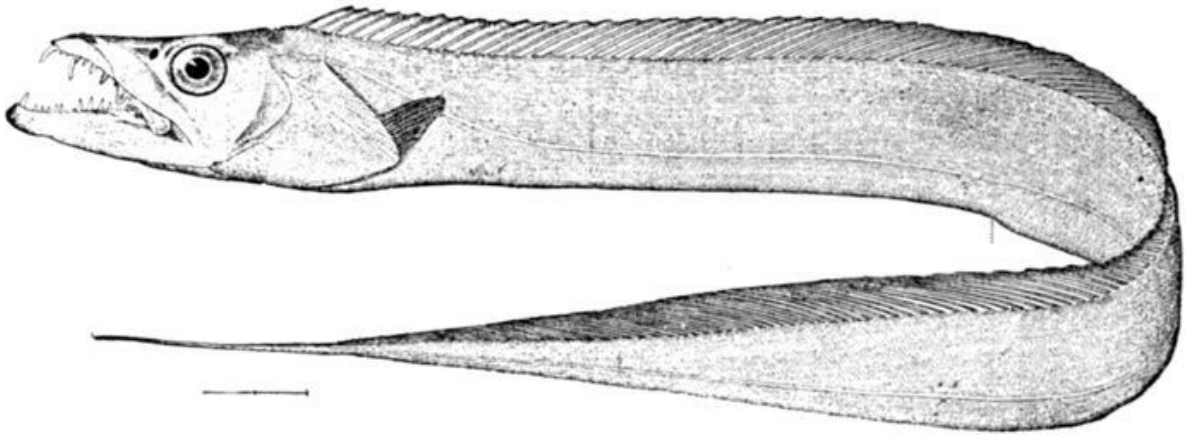

FIG. 209.—Cutlass-fish, *Trichiurus lepturus* Linnæus. St. Augustine, Fla.

The Palæorhynchidæ.—The extinct family of *Palæorhynchidæ* is found from the Eocene to the Oligocene. It contains very long and slender fishes, with long jaws and small teeth, the dorsal fin long and continuous. The species resembles the *Escolar* on the one hand and the sailfishes on the other, and they may prove to be ancestral to the *Istiophoridæ*. *Hemirhynchus deshayesi* with the upper jaw twice as long as the lower, sword-like, occurs in the Eocene at Paris; *Palæorhynchum glarisianum*, with the jaws both elongate, the lower

longest, is in the Oligocene of Glarus. Several other species of both genera are recorded.

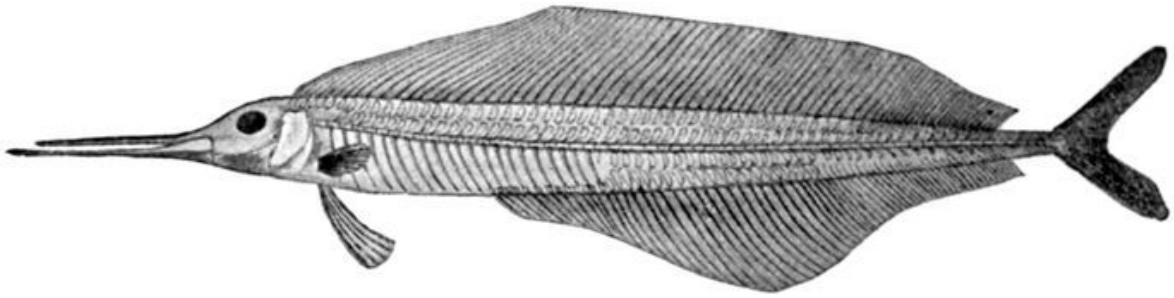

FIG. 210.—*Palæorhynchus glarisianus* Blainville. Oligocene. (After Woodward.)

The Sailfishes: Istiophoridæ.—Remotely allied to the cutlass-fishes and still nearer to the *Palæorhynchidæ* is the family of sailfishes, *Istiophoridæ*, having the upper jaw prolonged into a sword made of consolidated bones. The teeth are very feeble and the ventral fins reduced to two or three rays. The species are few in number, of large size, and very brilliant metallic coloration, inhabiting the warm seas, moving northward in summer. They are excellent as food, similar to the swordfish in this as in many other respects. The species are not well known, being too large for museum purposes, and no one having critically studied them in the field. *Istiophorus* has the dorsal fin very high, like a great sail, and undivided; *Istiophorus nigricans* is rather common about the Florida Keys, where it reaches a length of six feet. Its great sail, blue with black spots, is a very striking object. Closely related to this is *Istiophorus orientalis* of Japan and other less known species of the East Indies.

Tetrapturus, the spearfish, has the dorsal fin low and divided into two parts. Its species are taken in most warm seas, *Tetrapturus imperator* throughout the Atlantic, *Tetrapturus amplus* in Cuba, *Tetrapturus mitsukurii* and *Tetrapturus mazara* in Japan. These much resemble swordfish in form and habits, and they have been known to strike boats in the same way.

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